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Article

Effect of foliar spraying with seaweed extract (*Halamphora coffeaeformis*) and Nanosize fertilizer on growth, yield, and fruit quality of Flame Seedless grapevines

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Abstract

The present study was conducted during three successive seasons, 2020, 2021, and 2022 on thirty-six uniform 6-year-old Flame seedless grapevines in a Private vineyard in the Gohaina region, Sohag, Egypt. This study examined how grapevines respond physiologically, in terms of growth, yield, and quality, to Hydrogen Cyanamide and seaweed extract (*Halamphora coffeaeformis*) as dormancy breaking, as well as Nano fertilizers (nano Fe+ Zn), *H.coffeaeformis* and conventional fertilizers (EDTA Fe + Zn) applied three times at on the same vines at fruit set, berry size 6:8 mm and at veraison stage as single or combined. As a result, the maximum value of growth and yield parameters and chemical characteristics were recorded to combined application of dormix 5% the first week of Jan.× *H.coffeaeformis* at 1ml/l and (Nano Fe + Zn)1$_{ppm}$ (as an average of the three studied seasons) aspects than using each material alone. So, it is concluded that the combined foliar application dormix 5% first week of Jan. once and *H. coffeaeformis* at 1ml/l and (Nano Fe + Zn) 1$_{ppm}$ applied three times on the same vines at fruit set, berry size 6:8 mm and at veraison stage (Coloring 10 to 15% of the berries) led to clear enhancements in the majority of the tested vegetative and fruiting parameters of Flame seedless grapevines.

Keywords: Nano-fertilizers, Nano-iron, Nano-zinc, *Halamphora coffeaeformis*, seaweed extract.

1. Introduction

Grape (*Vitis vinifera* L.) belongs to the plant family Vitaceae. It is one of the most significant commercial fruit crops grown in temperate, tropical regions (Gowda *et al., 2008*). The total world area of grapes reached 6.85 million hectares, with a total production of 79.51 million tons of fruits per year (F.A.O., 2021). In Egypt, only citrus crops come before grapes as the second fruit crop. Because grape growers received a high net return, their cultivated area grew rapidly in the last two decades. The total cultivated area of grapes was about 190486 feddans (fed.) with a production of 1594782 tons, and productivity is 9.13 tons/fedden. (Central Agency for Public Mobilization and Statistics, Egypt 2021).

The grapevine is widely grown in tropical and subtropical regions, such as Upper Egyptian regions. In these regions, the bud breaks chilling requirements still need to be met, resulting in late leafing, irregular sprouting, decreased yield, uneven maturation, and delayed harvests, which result in severe economic losses. For regular bud growth to occur, temperatures must be below 7 °C for between 50 and 400 hours, depending on the type of grapevine (Pouget, 1963). According to several studies (Muhtaseb & Ghnaim, 2008; and Trejo-Martnez *et al.,* 2009), hydrogen cyanamide, an effective rest-breaking treatment for grapevines, has been used successfully to supplement chilling and improve bud burst and fertility percentage, growth, and yield.

Despite these benefits, hydrogen cyanamide is not permitted in organic grape production protocols, particularly in the European Union, Egypt's main export market. As a result, environmentally friendly and operator-safe bud break as Dormex, suitable for organic table grape production, is required. *H. coffeaeformis* Algal extracts caused highly significant changes in major and minor fractions of phenolic compounds, vanillic, chlorogenic, and caffeic acids. That led to significant growth promoters that are as effective as yield, carbohydrates, and various chemical constituents of plants in response to the algal extracts applications (Amer *et al.,* 2019). The essential compounds such as tannins, antioxidants, amino acids, vitamins, alcohols, phenolic compounds, caffeine, and minerals pan essential functions in plant metabolism. They are responsible for enhancing bud breaking, growth, and fruiting of most fruit crops (Balbaa *et al.,* 1976).

In sustainable agriculture practices, recently, many agents have been tested for their biostimulant or biofertilizer effects to promote plant growth. Seaweed extracts, one of the most frequently tested substances, have been demonstrated as an organic farm input in sustainable agriculture since they are ecologically safe and benign. Seaweed extracts contain several substances that promote plant growth, such as auxins, cytokinins, betaines, and gibberellins, as well as organic substances, such as amino acids, micronutrients, and trace elements, which can improve crop yield and quality (Khan *et al.,* 2009; Craigie, 2011; Arioli *et al.,* 2015; Battacharyya *et al.,* 2015).

Nanotechnology monitors a leading agricultural controlling process, especially by its small dimension. Additionally, many potential benefits, such as enhancement of food quality and safety, reduction of agricultural inputs, enrichment of absorbing nanoscale nutrients from the soil, etc., allow the application of nanotechnology to be a resonant encumbrance. Nanotechnology has been recognized as an efficient enhancement in the agricultural field because of its unique physicochemical properties; nanomaterials are increasingly used in agriculture to enhance the biomass of plants because of their small size a large surface area. The ambition of nanomaterials in agriculture is to reduce the amount of spread chemicals, minimize nutrient losses in fertilization, and increase yield through pest and nutrient management. (Sabir, *et al.,* 2014; Prasad *et al.,* 2017; Allam 2017; He *et al.,* 2018). The uptake of nanoparticles (N.P.s) is estimated to be 15-20 times more than conventional bulk particles (Rajput *et al*., 2018). Zinc Oxide Nanoparticles (ZnO N.P.s) are nano-scaled micro-nutrients used in low concentrations and play an essential role in plant functions. ZnO N.P.s enhance the growth characteristics and fruit quality of many plants (Prasad *et al.,* 2012; Tarafdar *et al.,* 2014; Venkatachalam *et al.,* 2017; Allam, 2018; Rossi *et al.,* 2019; El-Said *et al.,* 2019; Abou-Zaid and Shaaban 2019 and Abou El-Nasr *et al.,* 2021). Zinc is required for the activity of different enzymes, including dehydrogenases, aldolases, isomerases, transphosphorylases, R.N.A. and D.N.A. polymerases, cell division, maintenance of membrane structure and photosynthesis, and also acts as a regulatory cofactor in protein synthesis (Marschner, 2012). Vegetative and fruiting characters were registered maximum through applying ZnO N.P.s (1.2 ppm) compared to conventional fertilizers (ZnSO4 and Zn EDTA) in grapes cv. Flame Seedless (El-Said *et al.,* 2019).

Iron is an essential element for plant metabolism; it acts as a cofactor for various enzymes directly or indirectly involved in D.N.A. synthesis and respiration. Further, it also works as a cofactor for various enzymes involved in redox reactions, such as photosynthesis, respiration, and hormone synthesis (Barberon *et al.,* 2011). According to Álvarez *et al.* (2013), iron deficiency reduces the efficacy of photosynthetic and carbon fixation in plants, ultimately leading to reduced vegetative growth and crop yield. In addition, iron deficiency causes chlorosis in fruit trees (Nijjar, 1990). Mohamed (2020) showed that Using iron bulk or nano significantly increased yield, improved the cluster and berry traits, and improved leaf area, total chlorophyll, and leaf nutrient composition compared to control on the "Thompson seedless" grapevine.

This investigation was carried out to study the effect of seaweed extract the foliar application and nanosize fertilizer with mineral fertilization on vine growth and the feasibility of improving bud break, yield, cluster quality, and extended postharvest quality of grapevine to achieve higher economic returns under south Egypt.

2. Materials and Methods

The present study was conducted during three successive seasons, 2020, 2021, and 2022 on thirty-six uniform 6-years old Flame seedless grapevines in a private vineyard in the Gohaina region, Sohag Governorate, Egypt. The texture of the vineyard soil is loamy, and well-drained water since the water table depth is not less than two meters.

Table 1. Analysis of the tested vineyard soil

Measured character		Values			
Particle size distribution		Sand %	Silt %	Clay %	Texture grade
		24	38.20	37.80	Clay loam
Soil moisture content	Depth (cm)	0-15	15-30	30-45	45-60
	Field capacity	32.21	31.79	29.75	29.20
	Wilting point	13.75	13.20	12.41	11.19
	Available water	18.44	18.61	17.35	17.40
Bulk density (g/cm^3)		1.16	1.20	1.22	1.29
Soil chemical characteristics	$HCO3^-$	0.26	EC (ds m^{-1})		0.9
	Cl^-	0.28	pH		7.9
	$So4^{--}$	0.65	Available N (mg/kg)		17.5
	Ca^{++}	0.55	Available P (mg/kg)		10
	Mg^{++}	0.36	Available K (mg/kg)		178
	Na^+	0.23	Organic matter (%)		1.22
	K^+	0.12			

The chosen vines trained on the Y-Trellis (Y.T.) system, planted at a distance of 2x3 m, having similar trunk diameter, and irrigated with asurface irrigation system and N.P.K. fertigation were added as recommended by the Ministry of Agricultural. Cane pruning was applied in all seasons on the second week of December, leaving 48 eyes per vine (based on six fruiting canes x 6 eyes + 6 renewal spurs x 2 eyes).

In the experimental design in (Table 2), vines were set up in a completely randomized design by using a split-plot design; the dormancy breaking treatments (dormix 5% and *H. coffeeaeformis 2 ml/ l)* were arranged as the main plot, whereas the others application were laid out as sub plots, with six treatments which included control and three replications of one vine each. Grapevines were sprayed for foliar application in the subplots three times on the same vines at the fruit set, berry size 6:8 mm, and the veraison stage.

Table 2. Applied foliar treatments were as follows:

Treatments (A) Once implemented	Treatments (B) All treatments were applied three times on the same vines at fruit set, berry size 6:8 mm and at veraison stage.
Control	T1- control (Water).
	T2- Conventional fertilizers (Fe EDTA 500_{ppm} + Zn EDTA 500_{ppm}).
Dormex 5% at 1st week of Jan.	T3- Nano fertilizers (nano Fe 1_{ppm} + nano Zn 1_{ppm})
	T4- *H. coffeaeformis* 1 ml/L.
	T5- *H. coffeaeformis* 1ml/L + (Fe EDTA 500_{ppm} + Zn EDTA 500_{ppm}).
	T6- *H. coffeaeformis 1 ml/L + (nano Fe 1_{ppm} + nano Zn 1_{ppm}).*
	T1- control (Water).
	T2- Conventional fertilizers (Fe EDTA 500_{ppm} + Zn EDTA 500_{ppm}).
H. coffaeformis 2 ml/L at 1st week of Jan.	T3- Nano fertilizers (nano Fe 1_{ppm} + nano Zn 1_{ppm}).
	T4- *H. coffeaeformis* 1ml/L.
	T5 -*H. coffeaeformis* 1ml/L + (Fe EDTA 500_{ppm} + Zn EDTA 500_{ppm}).
	T6- *H. coffeaeformis 1 ml/L + (nano Fe 1_{ppm} + nano Zn 1_{ppm}).*

Seaweed extract: (*H. coffeaeformis*) in Table (3), the accepted name of the agla (*Amphora coffeaeformis*) according to the World Register of Marine Species (WoRMS), the algae was chosen for evaluating its biostimulants activity in this study according to previous investigators (Bhosle *et al.,* 1993& Faheed and Abd-El Fattah, 2008). The concentration of the algal solutions (1 g/L and 2 g/L) was suggested by (Amer *et al.,* 2019). The algae were purchased for this experiment from the Algae Production Unit, National Research Center, Egypt (N.R.C.).

Nanosize fertilizer: Iron oxide nanoparticles (Fe_3O_4 NPs) it is diameter is less than 50 nm; zinc Oxide Nanoparticles (ZnO N.P.s) with size ≤ 30 nm were confirmed by the transmission electron microscopy (HR-TEM) images for both. The two nanomaterials were purchased from Nano Gate Company, Nasr City, Cairo, Egypt. Nano-Fe and nano-Zn treatments were applied by foliar spraying at a concentration (1_{ppm}) in keeping with (El-Saber *et al.,* 2021; El-Said *et al.,* 2019) respectively.

Table 3. Chemical composition of *(H. coffeaeformis)* used in the study.

Algal composition (%)	Moisture	Carbohydrate	Protein	Ashes	Total Water soluble	Acid soluble
	89.5	33.60	15.74	30.43	13.11	16.24

Coubound	Concentration (µg g−1)	Macro elements (%)	
Gallic acid	28.31	N	5.41
Protocatechuic acid	14.24	P	1.32
p-Hydroxybenzoic acid	7.69	K	0.63
Catechin	38.08	Ca	26.9
Chlorogenic acid	9.89	Mg	2.29

Caffeic acid	12.26	Na	1.51
p-Coumaric acid	39.69	Micro elements (ppm)	
Cinnamic acid	12.33	Fe	7.89
Total chlorophyll (T-Chl)	20.68	Mn	1.10
Total carotenoids (TCAR)	15.6	Zn	13.52
		Cu	0.46

Conventional fertilizers: Iron EDTA (Fe EDTA) and Zinc EDTA (Zn EDTA), the two micronutrients, were bought from Agrico International Company, Giza, Egypt. The manufacturer's suggested concentration for foliar application (500 $_{ppm}$) for both iron and zinc EDTA.

The following parameters were assessed for this study:

.21. Vegetative growth determinations:

Four new shoots were randomly chosen per vine to measure the following parameters e at the end of the growing season:

a. Budburst (%)

b. Shoot Length (cm)

c. the number of leaves per shoot.

d. Leaf area (cm^2): Calculating using the following equation outlined by Ahmed and Morsy (1999).

Leaf area (cm^2) = 0.45 (0.79 x diameter2) + 17.77.

2..1 Leaf chemical analysis:

a. To determine the mineral content of each vine's 20 leaves, including the blade and petiole (the sixth leaf from the shoot tip), a sample was taken in mid-July. First, the leaves were cleaned in distilled water and then baked at 60 to 70 °C until their weight remained constant. The dried samples were ground in a stainless steel knife mill, and 0.2 grams of each sample's ground material were then digested with a solution of perchloric: sulphuric acid1:10(v/v) according to Jackson (1967). Nitrogen was determined as the method described by Pregl (1945), while phosphorus was colourimetrically determined as the method of Truog and Meyer (1929), potassium was determined using a flame photometer according to the method of Mason (1963), and iron and zinc were measured using the atomic absorption apparatus according to the method of Cottenie *et al.* (1982).

b. Chlorophyll: Ten leaves were opposite to the first basal clusters on the recent shoots according to Balo *et al.* (1988) and were taken in the first week of May for determining chlorophylls a and b (mg/ 1.0 g F.W.). Accurately weighted 0.5g of fresh plant leaf sample was taken and homogenized in tissue homogenizer with 10 ml of extractant solvent Ethanol 95%. The homogenized sample mixture was centrifuged at 10,000 rpm for 15min. The supernatant was separated, and 0.5 ml was mixed with 4.5 ml of the respective solvent. The solution mixture was analyzed for Chlorophyll-a and Chlorophyll-b content in a spectrophotometer (Parkin). The methods described by (Sumanta *et al.,* 2014). The optical densities of pigments (chlorophylls a and b) were measured colourimetrically at 664 and 649 nm wavelengths, respectively. These pigments were calculated using the following equations (mg/L.) Chlorophyll a = (13.36 x E664) – (5.19 x E649).

Chlorophyll b = (27.43 x E649) – (8.12 x E664).

Total chlorophylls = chlorophyll a+ chlorophyll b.

Where E = optical density at a given wavelength.

2.3. Yield parameters

Four clusters per vine were harvested at the ripening stage when juice TSS% reached 16% in 50% of treatments to determine the average of No. of clusters/vine, yield/vine (kg.), the weight of 100 berries (g), and the shot berries number/cluster.

2.4. Berry chemical analysis

A hand refractometer determined the total soluble solids (T.S.S. %) in the juice. Then T.S.S./acidity ratio was measured.

2.5. Chemical analysis:

a. Berries skin content of total anthocyanin.

Berry skin anthocyanins (mg/100g fresh weight) were determined according to Husia *et al.* (1965).

b. Total carbohydrate percentage in the canes.

Total carbohydrates were determined colourimetrically at a wavelength of 490 nm using the phenol-sulphuric acid method (Smith *et al*., 1956).

2.6. Statistical analysis: Obtained data were subjected to analysis of variances (ANOVA) according to 40 using the M.S.T.A.T. program. Duncan Multiple Range test 41 was used to compare between means at the probability of 5 %.

3. Results and Discussion

3.1. Vegetative growth

The data presented in Tables (4, 5, 6, 7, and 8) revealed that treating the vines with Seaweed extract, nanosize fertilizers (Fe, Zn N.P.s), and conventional fertilizers (Fe, Zn EDTA) significantly enhanced the percentages of bud burst (%), main shoot length (cm), the number of leaves/shoot, leaf area (cm^2) and the weight of pruning wood (kg/vine) compared with control. However, the statistical analysis pointed to non-significant differences for the bud burst (%) interaction between the treatments; the highest data was recorded by Dormex × *H. coffeaeformis* (99.31, 98.61, and 98.71%). Moreover, there were significant differences due to the main shoot length (cm), leaf area (cm2), and the number of leaves/shoot due to the interaction between the check treatments, the maximum values in the main shoot length (139.6, 145.6 and 143.3 cm), the number of leaves/shoot (32.23, 33.08 and 32.66), leaf area (133.3, 142.8 and 135.8 cm^2) and the weight of pruning wood (2.31, 2.80 and 2.75 kg/vine) were recorded by Dormex × *H. coffeaeformis* + Nano (Fe + Zn) in 2020, 2021 and 2022 seasons, respectively. These data are in harmony with those reported by Omran *et al.* (2005); Faheed and Abd-El Fattah (2008); Abd El Moniem and Abd-Allah (2008); Arora *et al.* (2011); Abo El-Ez *et al.* (2018); Arioli *et al., (*2020) and Hussain *et al., (*2021).

Table 4. Effect of foliar spray with Seaweed extract, nanosize fertilizers (Fe, Zn NPs), and conventional fertilizers (Fe, Zn EDTA) single or mixture on the percentages of bud burst % of Flame seedless grapevines during 2020, 2021 and 2022 seasons.

Treatments	2020		2021		2022	
	Dormex	*H. coffeaeformis*	Dormex	*H.coffeaeformis*	Dormex	*H.coffeaeformis*
T1	74.30^{d}	74.30^{d}	79.17^{e}	79.17^{e}	74.31^{c}	74.31^{c}
T2	97.22^{ab}	93.06^{bc}	96.5^{abc}	92.97^{d}	97.22^{a}	90.97^{b}
T3	97.22^{ab}	93.75^{bc}	97.22^{ab}	93.06^{d}	97.92^{a}	93.06^{b}
T4	99.31^{a}	92.36^{c}	98.61^{a}	93.75^{cd}	98.71^{a}	93.05^{b}
T5	96.5^{abc}	93.75^{bc}	97.92^{a}	93.75^{cd}	98.61^{a}	92.36^{b}
T6	97.22^{ab}	93.06^{bc}	97.22^{ab}	94.4^{bcd}	97.22^{a}	92.36^{b}

Table 5. Effect of foliar spray with Seaweed extract, nanosize fertilizers (Fe, Zn NPs), and conventional fertilizers (Fe, Zn EDTA) single or mixture on the main shoot length (cm) of Flame seedless grapevines during 2020, 2021 and 2022 seasons.

Treatments	2020		2021		2022	
	Dormex	*H. coffeaeformis*	Dormex	*H.coffeaeformis*	Dormex	*H.coffeaeformis*
T1	110.3^{f}	110.3^{f}	112.2^{g}	112.2^{g}	113.6^{f}	113.6^{f}
T2	128.1^{d}	122.8^{e}	128.4^{e}	122.5^{f}	127.9^{d}	121.5^{e}
T3	130.7^{d}	128.6^{d}	136.2^{cd}	128.2^{e}	134.9^{bc}	129.1^{d}
T4	135.1^{bc}	129.8^{d}	139.7^{bc}	133.5^{de}	136.6^{b}	130.5^{cd}
T5	137.8^{ab}	130.9^{d}	142.9^{ab}	136.6^{cd}	138.8^{ab}	131.4^{cd}
T6	139.6^{a}	134.8^{c}	145.6^{a}	139.9^{bc}	143.3^{a}	137.4^{b}

Table 6. Effect of foliar spray with Seaweed extract, nanosize fertilizers (Fe, Zn NPs), and conventional fertilizers (Fe, Zn EDTA) single or mixture on the number of leaves per shoot of Flame seedless grapevines during 2020, 2021 and 2022 seasons.

Treatments	2020		2021		2022	
	Dormex	*H. coffeaeformis*	Dormex	*H.coffeaeformis*	Dormex	*H.coffeaeformis*
T1	17.00^{h}	17.00^{h}	19.58^{g}	19.58^{g}	18.43^{h}	18.43^{h}
T2	21.93^{f}	19.54^{g}	24.80^{f}	21.43^{g}	22.89^{g}	19.99^{h}
T3	24.77^{de}	22.70^{ef}	29.23^{cde}	26.00^{f}	25.00^{ef}	23.43^{fg}
T4	28.03^{bc}	24.33^{e}	31.77^{abc}	27.11^{def}	28.06^{cd}	25.11^{ef}
T5	29.71^{b}	26.63^{cd}	32.87^{ab}	26.89^{ef}	30.33^{b}	26.89^{de}
T6	32.23^{a}	28.30^{bc}	33.08^{a}	29.97^{bcd}	32.66^{a}	28.99^{bc}

Mean separation within each column by Duncan multiple ranges (0.05); Means with similar letters are insignificantly different.

Table 7. Effect of foliar spray with Seaweed extract, nanosize fertilizers (Fe, Zn NPs), and conventional fertilizers (Fe, Zn EDTA) single or mixture on the leaf area (cm^2) of Flame seedless grapevines during 2020, 2021 and 2022 seasons.

Treatments	2020		2021		2022	
	Dormex	*H. coffeaeformis*	Dormex	*H.coffeaeformis*	Dormex	*H.coffeaeformis*
T1	97.5^{f}	97.5^{f}	117.7^{g}	117.7^{g}	106.9^{e}	106.9^{e}
T2	118.1^{de}	115.8^{e}	124.0^{ef}	122.8^{f}	120.0^{d}	117.2^{d}
T3	123.2^{c}	119.9^{d}	127.8^{cde}	125.4^{def}	125.1^{c}	120.4^{d}
T4	124.7^{c}	124.2^{c}	128.5^{cd}	126.7^{cde}	127.1^{bc}	125.5^{c}
T5	129.7^{b}	127.5^{b}	130.0^{c}	129.3^{cd}	129.3^{b}	127.8^{bc}
T6	133.3^{a}	128.3^{b}	142.8^{a}	134.4^{b}	135.8^{a}	129.8^{b}

Table 8. Effect of foliar spray with Seaweed extract, Nano size fertilizers (Fe, Zn NPs), and conventional fertilizers (Fe, Zn EDTA) single or mixture on the weight of pruning wood (kg/vine) of Flame seedless grapevines during 2020, 2021, and 2022 seasons.

Treatments	2020		2021		2022	
	Dormex	*H. coffeaeformis*	Dormex	*H.coffeaeformis*	Dormex	*H.coffeaeformis*
T1	1.37^{e}	1.37^{e}	1.56^{g}	1.56^{g}	1.40^{g}	1.40^{g}
T2	1.53^{e}	1.45^{e}	1.88^{ef}	1.74^{fg}	1.80^{ef}	1.70^{f}
T3	1.72^{d}	1.53^{e}	2.11^{cde}	1.99^{def}	2.03^{d}	1.86^{e}
T4	1.81^{cd}	1.74^{cd}	2.36^{bc}	2.14^{cd}	2.22^{c}	2.03^{d}
T5	2.11^{b}	1.91^{c}	2.60^{ab}	2.33^{c}	2.51^{b}	2.31^{c}
T6	2.31^{a}	2.10^{b}	2.80^{a}	2.59^{ab}	2.75^{a}	2.48^{b}

Mean separation within each column by Duncan multiple ranges (0.05); Means with similar letters are insignificantly different.

3.2. Leaf and canes chemical composition

Obtained data in Tables (9, 10, 11, 12, 13, 14, and 15) clearly show the effect of treating the vines with Seaweed extract, nanosize fertilizers (Fe, Zn N.P.s), and conventional fertilizers (Fe, Zn EDTA) significantly enhanced the leaf content of N, P, K, Fe, Zn, total chlorophylls and total carbohydrate (%) in canes compared with control. Furthermore, the Statistical analysis declared significant differences for the leaf content of N, P, K, Fe, and Zn as the interaction between the treatments, the maximum values in the leaf content of N (2.00, 2.17, and 2.01 %), leaf content of P (0.309, 0.424 and 0.387 %), leaf content of K (1.47, 1.83 and 1.68 %), leaf content of Fe (138.5, 139.2 and 139.1 mg/100g), leaf content of Zn (26.10, 27.51 and 26.50 mg/100g), total chlorophylls (4.39, 4.94 and 4.59 mg/g F.W.) and total carbohydrates (%) in canes (32.33, 36.43 and 34.80 %) were recorded by Dormex × *H. coffeaeformis* + Nano (Fe + Zn). in 2020, 2021 and 2022 seasons, respectively. These results are consistent with those reported by Zhang and Ervin (2004); Abd El Moniem and Abd-Allah (2008); Mahmood-ul-Hassan (2008); Papenfus *et al*. (2013); Ahmed *et al.* (2014), Arioli *et al. (*2015), Battacharyya *et al. (*2015); Kamiab and Zamani-bahramabadi (2016); Stino *et al.(*2017); Mattner *et al. (*2018); Amer *et al.,* (2019); Arioli *et al.* (2020); Rouphael and Colla (2020); Mohamed (2020); Alalaf *et al.,* (2020), Ali *et al.*(2021); Hussain *et al. (*2021) and Mohebbi *et al.* (2022).

Table 9. Effect of foliar spray with Seaweed extract, Nano size fertilizers (Fe, Zn NPs), and conventional fertilizers (Fe, Zn EDTA) single or mixture on the leaf content of N (%). of Flame seedless grapevines during 2020, 2021, and 2022 seasons.

Treatments	2020		2021		2022	
	Dormex	*H. coffeaeformis*	Dormex	*H.coffeaeformis*	Dormex	*H.coffeaeformis*
T1	1.13^{i}	1.13^{i}	1.18^{g}	1.18^{g}	1.12^{h}	1.12^{h}
T2	1.22^{gh}	1.17^{hi}	1.35^{f}	1.27^{fg}	1.32^{f}	1.23^{g}
T3	1.27^{g}	1.23^{gh}	1.48^{e}	1.36^{f}	1.42^{e}	1.32^{f}
T4	1.54^{e}	1.40^{f}	1.78^{c}	1.58^{d}	1.65^{d}	1.43^{e}
T5	1.75^{c}	1.63^{d}	1.88^{b}	1.73^{c}	1.80^{c}	1.67^{d}
T6	2.00^{a}	1.90^{b}	2.17^{a}	1.92^{b}	2.01^{a}	1.89^{b}

Table 10. Effect of foliar spray with Seaweed extract, nanosize fertilizers (Fe, Zn NPs), and conventional fertilizers (Fe, Zn EDTA) single or mixture on the leaf content of P (%) of Flame seedless grapevines during 2020, 2021 and 2022 seasons

Treatments	2020		2021		2022	
	Dormex	*H. coffeaeformis*	Dormex	*H.coffeaeformis*	Dormex	*H.coffeaeformis*
T1	0.135^{g}	0.135^{g}	0.145^{g}	0.145^{g}	0.145^{g}	0.145^{g}
T2	0.153^{ef}	0.140^{fg}	0.223^{f}	0.210^{f}	0.197^{f}	0.181^{f}
T3	0.164^{e}	0.145^{fg}	0.227^{f}	0.216^{f}	0.216^{e}	0.198^{f}
T4	0.266^{c}	0.243^{d}	0.350^{d}	0.324^{e}	0.30^{cd}	0.287^{d}
T5	0.295^{ab}	0.273^{c}	0.394^{b}	0.375^{c}	0.317^{c}	0.304^{c}
T6	0.309^{a}	0.291^{b}	0.424^{a}	0.402^{b}	0.387^{a}	0.361^{b}

Table 11. Effect of foliar spray with Seaweed extract, nanosize fertilizers (Fe, Zn NPs), and conventional fertilizers (Fe, Zn EDTA) single or mixture on the leaf content of K (%) of Flame seedless grapevines during 2020, 2021 and 2022 seasons.

Treatments	2020		2021		2022	
	Dormex	*H. coffeaeformis*	Dormex	*H.coffeaeformis*	Dormex	*H.coffeaeformis*
T1	1.13^{f}	1.13^{f}	1.16^{g}	1.16^{g}	1.14^{j}	1.14^{j}

T2	1.26cd	1.17ef	1.32ef	1.27f	1.30h	1.19i
T3	1.27cd	1.22de	1.34e	1.27f	1.32g	1.20i
T4	1.46a	1.38b	1.66c	1.55d	1.55d	1.43f
T5	1.38b	1.29c	1.78ab	1.63c	1.62b	1.51e
T6	1.47a	1.40b	1.83a	1.75b	1.68a	1.58c

Mean separation within each column by Duncan multiple ranges (0.05); Means with similar letters are insignificantly different.

Table 12. Effect of foliar spray with Seaweed extract, nanosize fertilizers (Fe, Zn NPs), and conventional fertilizers (Fe, Zn EDTA) single or mixture on the leaf content of Fe (mg/100g) of Flame seedless grapevines during 2020, 2021 and 2022 seasons.

Treatments	2020		2021		2022	
	Dormex	*H. coffeaeformis*	Dormex	*H.coffeaeformis*	Dormex	*H.coffeaeformis*
T1	61.7i	61.7i	74.3h	74.3h	69.2k	69.2k
T2	115.8g	111.8h	121.8f	115.8g	116.8i	112.1j
T3	125.1de	117.9f	127.1d	120.2f	125.9f	119.7h
T4	127.5bc	119.7f	129.3c	124.0e	127.8d	123.0g
T5	126.5cd	123.9e	132.3b	127.7cd	128.8c	126.4e
T6	138.5a	129.2b	139.2a	131.4b	139.1a	130.8b

Table 13. Effect of foliar spray with Seaweed extract, nanosize fertilizers (Fe, Zn NPs), and conventional fertilizers (Fe, Zn EDTA) single or mixture on the leaf content of Zn (mg/100g) of Flame seedless grapevines during 2020, 2021 and 2022 seasons.

Treatments	2020		2021		2022	
	Dormex	*H. coffeaeformis*	Dormex	*H.coffeaeformis*	Dormex	*H.coffeaeformis*
T1	14.56h	14.56h	15.03i	15.03i	14.68i	14.68i
T2	18.82ef	17.30g	18.99g	17.88h	18.79g	17.45h
T3	19.62e	18.04fg	20.74ef	19.24g	19.98f	18.81g
T4	20.74d	19.46e	21.24de	20.14f	20.81e	19.69f
T5	22.78c	21.12d	23.30c	21.96d	23.35c	21.69d
T6	26.10a	23.75b	27.51a	24.57b	26.50a	24.10b

Table 14. Effect of foliar spray with Seaweed extract, nanosize fertilizers (Fe, Zn NPs), and conventional fertilizers (Fe, Zn EDTA) single or mixture on the total Chlorophyll (mg/g F.W.) of Flame seedless grapevines during 2020, 2021 and 2022 seasons.

Treatments	2020		2021		2022	
	Dormex	*H. coffeaeformis*	Dormex	*H.coffeaeformis*	Dormex	*H.coffeaeformis*
T1	1.79k	1.79k	2.24j	2.24j	2.10j	2.10j
T2	2.16j	2.49i	3.36h	2.94i	3.20h	2.94i
T3	2.97g	2.63h	3.62f	3.55g	3.46g	3.19h
T4	3.68e	3.44f	4.22d	4.04e	4.05e	3.80f
T5	4.11c	4.00d	4.74b	4.24d	4.46b	4.13d
T6	4.39a	4.18b	4.94a	4.35c	4.59a	4.31c

Mean separation within each column by Duncan multiple ranges (0.05); Means with similar letters are insignificantly different.

Table 15. Effect of foliar spray with Seaweed extract, nanosize fertilizers (Fe, Zn NPs), and conventional fertilizers (Fe, Zn EDTA) single or mixture on the total carbohydrate (%) of Flame seedless grapevines during 2020, 2021 and 2022 seasons.

Treatments	2020		2021		2022	
	Dormex	*H. coffeaeformis*	Dormex	*H.coffeaeformis*	Dormex	*H.coffeaeformis*
T1	18.90^{h}	18.90^{h}	21.33^{i}	21.33^{i}	20.33^{i}	20.33^{i}
T2	24.00^{f}	22.97^{g}	26.33^{g}	24.30^{h}	25.50^{g}	23.77^{h}
T3	25.13^{e}	23.90^{f}	27.17^{f}	26.00^{g}	26.33^{f}	25.13^{g}
T4	26.67^{d}	25.83^{de}	29.33^{e}	27.50^{f}	28.50^{e}	26.83^{f}
T5	30.67^{b}	29.60^{c}	33.47^{b}	31.00^{d}	33.23^{b}	30.33^{d}
T6	32.33^{a}	31.00^{b}	36.43^{a}	32.50^{c}	34.80^{a}	32.17^{c}

3.3. Yield characteristics

A perusal of data depicted in Table (16, 17, 18, and 19) show the impact of treating the vines with Seaweed extract, nanosize fertilizers (Fe, Zn N.P.s), and conventional fertilizers (Fe, Zn EDTA) significantly improved the Number of clusters/vine, yield/vine (kg.), the weight of 100 berries (g) and decrease the shot berries number/cluster compared with control. The statistical analysis expressed significant differences for the previous parameters due to the interaction between the treatments, the highest values in the number of clusters/vine (24.0, 30.3, and 27.6), yield/vine (7.37, 11.29, and 9.42 kg), the weight of 100 berry (227.4, 253.3, and 242.4 g) and the lowest values in the shot berries number/cluster (5.27, 2.44, and 2.55) were recorded by Dormex × *H. coffeaeformis* + Nano (Fe + Zn) in the three seasons, respectively. These findings are in harmony with those reported by Abd El Moniem and Abd-Allah (2008); Stino *et al. (*2017); Mattner *et al. (*2018); Amer *et al. (*2019), Ghadakchi *et al.* (2019), Arioli *et al., (*2020); Hussain *et al., (*2021) and Abo El-Ezz *et al.,* (2022).

Table 16. Effect of foliar spray with Seaweed extract, nanosize fertilizers (Fe, Zn NPs), and conventional fertilizers (Fe, Zn EDTA) single or mixture on the number of clusters/vine of Flame seedless grapevines during 2020, 2021, and 2022 seasons.

Treatments	2020		2021		2022	
	Dormex	*H. coffeaeformis*	Dormex	*H.coffeaeformis*	Dormex	*H.coffeaeformis*
T1	14.6^{g}	14.6^{g}	16.6^{f}	16.6^{f}	16.0^{g}	16.0^{g}
T2	19.3^{def}	17.3^{f}	22.3^{cde}	20.6^{e}	20.6^{def}	19.6^{f}
T3	20.3^{cde}	18.6^{ef}	24.0^{c}	21.6^{de}	23.0^{bcd}	20.3^{ef}
T4	21.3^{bcd}	19.0^{ef}	27.0^{b}	23.6^{cd}	24.0^{bc}	21.3^{def}
T5	23.0^{ab}	22.0^{abc}	27.6^{b}	24.3^{c}	25.3^{ab}	22.6^{cde}
T6	24.0^{a}	22.6^{ab}	30.3^{a}	27.6^{b}	27.6^{a}	24.3^{bc}

Mean separation within each column by Duncan multiple ranges (0.05); Means with similar letters are insignificantly different.

Table 17. Effect of foliar spray with Seaweed extract, nanosize fertilizers (Fe, Zn NPs), and conventional fertilizers (Fe, Zn EDTA) single or mixture on the yield/vine (kg.) of Flame seedless grapevines during 2020, 2021, and 2022 seasons.

Treatments	2020		2021		2022	
	Dormex	*H. coffeaeformis*	Dormex	*H.coffeaeformis*	Dormex	*H.coffeaeformis*
T1	2.33^{h}	2.33^{h}	3.05^{g}	3.05^{g}	2.67^{f}	2.67^{f}
T2	4.00^{ef}	3.50^{g}	4.79^{def}	4.10^{f}	4.35^{de}	3.79^{e}
T3	4.36^{e}	3.87^{fg}	5.43^{d}	4.44^{ef}	4.96^{d}	4.24^{de}
T4	4.94^{d}	4.26^{ef}	6.88^{c}	5.08^{de}	5.73^{c}	4.51^{de}
T5	6.46^{b}	5.65^{c}	9.21^{b}	7.03^{c}	8.11^{b}	6.39^{c}
T6	7.37^{a}	6.88^{b}	11.29^{a}	9.50^{b}	9.42^{a}	7.91^{b}

Table 18. Effect of foliar spray with Seaweed extract, nanosize fertilizers (Fe, Zn NPs), and conventional fertilizers (Fe, Zn EDTA) single or mixture on the shot berries number/cluster of Flame seedless grapevines during 2020, 2021, and 2022 seasons.

Treatments	2020		2021		2022	
	Dormex	*H. coffeaeformis*	Dormex	*H.coffeaeformis*	Dormex	*H.coffeaeformis*
T1	14.11^{a}	14.11^{a}	13.89^{a}	13.89^{a}	15.68^{a}	15.68^{a}
T2	7.94^{cd}	10.37^{b}	6.3^{cde}	8.44^{bc}	6.89^{cd}	10.18^{b}
T3	6.7^{cde}	8.15^{c}	6.0^{cde}	9.86^{b}	6.4^{cde}	7.84^{c}
T4	6.7^{cde}	7.94^{cd}	4.44^{def}	6.1^{cde}	5.11^{ef}	7.16^{cd}
T5	6.16^{de}	7.92^{cd}	3.22^{ef}	6.76^{bcd}	4.11^{fg}	7.18^{cd}
T6	5.27^{e}	6.36^{cde}	2.44^{f}	4.75^{def}	2.55^{g}	5.52^{def}

Table 19. Effect of foliar spray with Seaweed extract, nanosize fertilizers (Fe, Zn NPs), and conventional fertilizers (Fe, Zn EDTA) single or mixture on the weight of 100 berries (g) of Flame seedless grapevines during 2020, 2021, and 2022 seasons.

Treatments	2020		2021		2022	
	Dormex	*H. coffeaeformis*	Dormex	*H.coffeaeformis*	Dormex	*H.coffeaeformis*
T1	103.0^{g}	103.0^{g}	143.50^{g}	143.5^{g}	127.8^{e}	127.8^{e}
T2	181.2^{de}	172.40^{e}	218.2^{cd}	216.6^{d}	213.7^{c}	210.1^{c}
T3	186.2^{cd}	180.0^{de}	215.9^{d}	197.0^{e}	203.5^{cd}	204.5^{cd}
T4	194.4^{c}	157.2^{f}	223.9^{cd}	177.9^{f}	207.0^{c}	188.7^{d}
T5	208.4^{b}	185.2^{cd}	233.3^{bc}	213.6^{d}	232.8^{ab}	217.1^{bc}
T6	227.4^{a}	219.2^{a}	253.3^{a}	247.4^{ab}	242.4^{a}	241.6^{a}

Mean separation within each column by Duncan multiple ranges (0.05); Means with similar letters are insignificantly different.

4. Conclusions

It is concluded that the combined foliar application dormix 5% first week of Jan. once and *H. coffeaeformis* at 1ml/l and (Nano Fe + Zn) 1_{ppm} applied three times on the same vines at fruit set, berry size 6:8 mm and at veraison stage led to clear enhancements in the majority of the tested vegetative and fruiting parameters of Flame seedless grapevines.

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مقال

الملخص العربي

تأثير الرش الورقي بمستخلص الاعشاب البحرية (*Halamphora Coffeaeformis*) واسمدة النانو على نمو الكرمة والمحصول وجودة العنقود في صنف العنب فليم سيدلس

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أجريت هذه الدراسة خلال ثلاثة مواسم متتالية في الأعوام 2020 ،2021 و2022 على 36 كرمة عنب صنف فليم سيدلس. تمت التجربة في مزرعة خاصة بمركز جهينة بمحافظ سوهاج. تهدف الدراسة الى تقييم استجابة صفات العنب الخضرية و الثمرية للمعاملة ب كاسرات السكون (هيدروجين السيناميد ومستخلص طحلب الامفورا خلال طور السكون، بالإضافة الى الرش ورقياً ب أسمدة النانو (حديد + زنك) و مستخلص طحلب الامفورا و أسمده تقليدية في صورة مخلبية (حديد +زنك) ، تم رش هذه المركبات منفرده أو مخلوطة بعضها ثلاثة مرات متتالة على نفس الكرمات فى المواعيد الأتية: عند مرحلة العقد ، قطر حبات 6:8 مللي و عند مرحلة الطراوة . سجلت اعلى القيم للصفات الخضرية والثمرية لمعاملة (دورمكس 5% + طحلب الامفورا 1 مللى / لتر + أسمدة النانو (حديد+زنك) خلال الثلاثة مواسم مسجلةً نتائج اعلى من أي معاملة أخرى منفردة. تبين من هذه الدراسة أن تطبيق المعاملة بهديروجين السيناميد (درومكس) 5% خلال الأسبوع الأول من يناير مرة واحده، بالإضافة الى تطبيق الرش ورقياً بمخلوط (1مللى/ لتر من مستخلص طحلب الامفورا + 1 جزء في المليون من أسمدة النانو (حديد + زنك) ثلاثة مرات خلال: مرحلة العقد و قطر حبات 6:8 مللى وعند بداية مرحلة الطراوة، أدى الي تحسين بشكل ملحوظ الغالبية العظمى للصفات الخضرية والثمرية لصنف العنب الفليم سيدلس.

الكلمات المفتاحية: أسمدة النانو، نانو حديد، نانو زنك، مستخلص طحالب، طحلب الامفورا.